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SOME CORRELATIONS OF ONTOGENY AND PHYLOGENY IN THE BRACHIOPODA.

BY C. E. BEECHER.

The parallelism between the ontogeny and phylogeny in the Brachiopoda has been worked out in numerous instances.[1] To illustrate these, some more or less familiar genera may be taken as characteristic examples.

Lingula has been shown by Hall and Clarke (Pal. N. Y., Vol. VIII, 1892) to have had its inception in the Ordovician. In the ontogeny of both recent and fossil forms, the first shelled stage has a straight hinge line, nearly equal in length to the width of the shell. This stage may be correlated with the more ancient genus *Paterina*, from the lowest Cambrian. Subsequent growth produces a form resembling *Obolella*, a Cambrian and Lower Silurian genus. Then the linguloid type of structure appears at an adolescent period, and is completed at maturity. Thus, *Lingula* has ontogenetic stages corresponding to (1) *Paterina,* (2) *Obolella,* and (3) *Lingula,* of which the first two occur as adult forms in geological formations older than any known *Lingula.*

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[1] C. E. Beecher. Development of the Brachiopoda. Part I, Introduction. Am. Jour. Sci., Vol. XLI, April, 1891.

Development of the Brachiopoda. Part II, Classification of the Stages of Growth and Decline. Am. Jour. Sci., Vol. XLIV, August, 1892.

Development of Bilobites. Am. Jour. Sci., Vol. XLII, July, 1891.

Revision of the Families of Loop-bearing Brachiopoda. Trans. Conn. Acad. Sci., Vol. IX, May, 1893.

Deslongchamps e. Etudes critiques sur des Brachiopodes Nouveau ou peu connus, 1884.

Fischer and Œhlert. Brachiopodes: Mission Scientifique du Cap Horn, 1882–1883. Bull. Soc. Hist. Nat. d'Autun, vol. v, 1892.

Paterina represents the prototype of the Brachiopods. It shows no separate stages of growth in the shell, is found in the oldest fossiliferous rocks, and corresponds to the embryonic shelled condition (protegulum) of the class.

The genus *Orbiculoidea* of the Discinidæ first appears in the Ordovician and continues through the Mesozoic. The early stages in the ontogeny of an individual are, as in *Lingula,* first a *Paterina* stage, followed by an *Obolella* stage. Then, from the mechanical conditions of growth, a *Schizocrania*-like stage follows, and complete growth results in *Orbiculoidea.*

The elongate form of the shell in *Lingula* as well as in many other genera is determined by the length of the pedicle and freedom of motion. The discinoid, or discoid, form of *Orbiculoidea* and *Discinisca* among the Brachiopods, and *Anomia* among Pelecypods, is determined by the horizontal position of the valves, which are attached to an object of support by a more or less flexible, very short organ, a pedicle or byssus, without calcareous cementation. This mode of growth is characteristic of all thé discinoid genera, but as already shown, the early stages of Paleozoic *Orbiculoidea* have straight hinge lines and marginal beaks, and in the adult stages of the shell the beaks are usually subcentral and the growth holoperipheral. This adult discinoid form, which originated and was acquired through the conditions of fixation of the animals, has been accelerated in the recent *Discinisca,* so that it appears in a free swimming larval stage. Thus, a character acquired in adolescent and adult stages of Paleozoic species through the mechanical conditions of growth, appears by acceleration in larval stages of later forms before the assumption of the condition of fixation which first produced this character.

The two chief subfamilies of the Terebratellidæ undergo complicated series of metamorphoses in their brachial structure. Generic characters in this family are generally based upon the form and disposition of the brachia and their supports. The highest genera in one subfamily, which is austral in distribution, pass through stages correlated with the adult structure in the genera *Gwynia*, *Cistella*, *Bouchardia*, *Megerlina*, *Magas*, *Magasella*, and *Terebratella*, and reach their final development in *Magellania* and *Neothyris*. The higher genera in another subfamily, boreal in distribution, pass through metamorphoses correlated with the adult structures of *Gwynia*, *Cistella*, *Platidia*, *Ismenia*, *Mühlfeldtia*, *Terebratalia*, and *Dallina*. The first two stages in both subfamilies are related in the same manner to *Gwynia* and *Cistella*. The subsequent stages are different except the last two, so that the *Magellania* structure is similar in all respects to the *Dallina* structure, and *Terebratella* is like *Terebratalia*. Therefore, *Magellania* and *Terebratella* are respectively the exact morphological equivalents to, or are in exact parallelism with *Dallina* and *Terebratalia*.

The stages of growth of the genera belonging to the two subfamilies Dallininæ and Magellaniinæ are further correlated in the accompanying tables.

The simplest genus, *Gwynia*, as far as known, passes through no brachial metamorphoses, and has the same structure throughout the adolescent period, up to and including the mature condition. In the ontogeny of *Cistella*, the *gwyniform* stage, through acceleration, has become a larval condition. In *Platidia*, the *cistelliform* structure is accelerated to the immature period, and in *Ismenia* (representing an *ismeniform* type of structure in the higher genera), the *gwyniform* and *cistelliform* stages are larval, and the platidiform represents an adolescent condition. Similar comparisons may be made in the other genera. Progressively through each series, the adult structure of any genus forms the last immature stage of the next higher, until the highest member in its ontogeny represents serially, in its stages of growth, all the adult structures, with the larval and immature stages of the simpler genera. It is evident that in the identification of species belonging to the Terebratellidæ, whether recent or fossil, the strict specific characters

Morphogeny from Gwynia to Dallina.

Periods.	Stages.	Stages.	Stages.	Stages.	Stages.	Stages.	Stages.
Larval	gwyniform ?	gwyniform	gwyniform	gwyniform cistelliform	gwyniform cistelliform	gwyniform cistelliform	gwyniform cistelliform
Adolescent	gwyniform	cistelliform	cistelliform	platidiform	platidiform ismeniform	platidiform ismeniform mühlfeldtiform	platidiform ismeniform mühlfeldtiform terebrataliform
Mature	*Gwynia*	*Cistella*	*Platidia*	*Ismenia*	*Mühlfeldtia*	*Terebratalia*	*Dallina*

Morphogeny from Gwynia to Magellania.

Periods.	Stages.	Stages.	Stages.	Stages.	Stages.	Stages,	Stages.	Stages.
Larval	gwyniform?	gwyniform	gwyniform	gwyniform cistelliform	gwyniform cistelliform	gwyniform cistelliform	gwyniform cistelliform	gwyniform cistelliform
Adolescent	gwyniform	cistelliform	cistelliform	bouchardiform	bouchardiform megerliniform	bouchardiform megerliniform magadiform	bouchardiform megerliniform magadiform magaselliform	bouchardiform megerliniform magadiform magaselliform terebratelliform
Mature	*Gwynia*	*Cistella*	*Bouchardia*	*Megerlina*	*Magas*	*Magasella*	*Terebratella*	*Magellania*

must be given first consideration. Species, therefore, must be based upon surface ornaments, form and color, within certain limits, and genera only upon structural features developed through a definite series of changes, the results of which are permanent in individuals evidently fully adult.

In each line of progression in the Terebratellidæ, the acceleration of the period of reproduction, by the influence of environment, threw off genera which did not go through the complete series of metamorphoses, but are otherwise fully adult, and even may show reversional tendencies due to old age; so that nearly every stage passed through by the higher genera has a fixed representative in a lower genus. Moreover, the lower genera are not merely equivalent to, or in exact parallelism with, the early stages of the higher, but they express a permanent type of structure, as far as these genera are concerned, and after reaching maturity do not show a tendency to attain higher phases of development, but thicken the shell and cardinal process, absorb the deltidial plates, and exhibit all the evidences of senility.

EXPLANATION OF PLATE.

Morphogeny of Magellaniinæ.

The figures in the left hand column, A–H, represent the stages in the ontogeny of the brachial supports in *Magellania*, one of the highest genera of the family Terebratellidæ. In the right hand column are shown the adult, permanent, generic structures, corresponding to the stages of *Magellania.*

Terebratella passes through all the stages from A to G, *Magasella* from A to F, and so on, as far as known for each lower genus.

All figures are drawn of approximately the same length, to facilitate comparison, in consequence the younger stages are much enlarged.

Fig. A.—Early larval brachiopod, without calcified brachial supports, but with circlet of tentacles on lophophore. The *gwyniform* stage.

Fig. A1.—*Gwynia capsula* Jeffreys, a morphic equivalent of larval stage, figure A.

Fig. B.—Later stage of A, showing growth of septum and consequent introversion of edge of lophophore. *Cistelliform* stage.

Fig. B1.—*Cistella neapolitana* Scacchi, showing calcification of loop attached to septum, and other adult features. Morphic equivalent of stage B of *Magellania.*

Fig. C.—Third stage of *Magellania,* with small ring on septum. *Bouchardiform* stage.

Fig. Ca.—Side view of same.

Fig. C1.—*Bouchardia rosea* Mawe, adult, showing ring on septum as in C.

Fig. D.—*Megerliniform* stage of *Magellania.*

Fig. Da.—Side view, showing growth of descending branches as prongs on side of septum.

Fig. D1.—*Megerlina lamarckiana* Davidson, adult form of brachial supports.

Fig. E.—*Magadiform* stage of *Magellania,* showing completion of descending branches.

Fig. E1.—*Magas pumilus* Sowerby, the Cretaceous prototype of this structure.

Fig. F.—*Magaselliform* stage, showing union of descending and ascending branches.

Fig. F1.—*Magasella cumingii* Davidson.

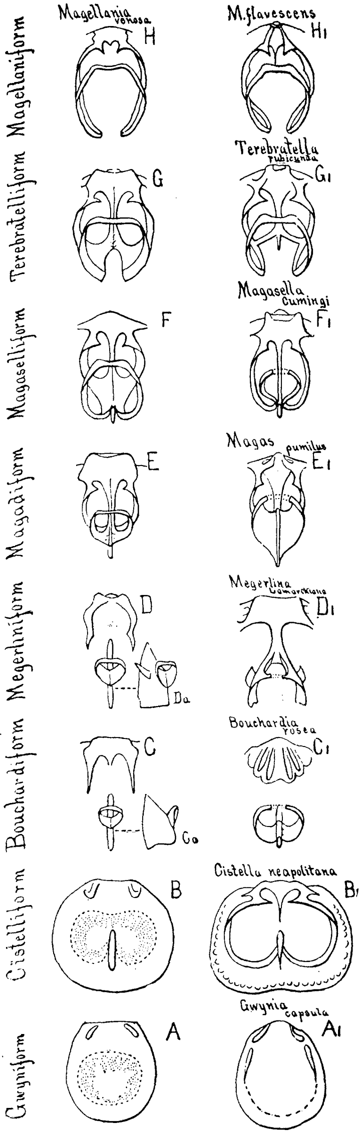
Fig. G.—*Terabratelliform* stage, representing the finished type of structure in *Terebratella dorsata.*

Fig. G1.—*Terebratella rubicunda.* Morphically equivalent to G, but showing more mature features.

Fig. H.—Final stage of *Magellania venosa,* produced by resorption of the septum and connecting bands of the *terebratelliform* stage.

Fig. H1.—*Magellania flavescens* Lamarck.

PLATE XV.



Parallelism in Brachiopoda, (Magellania series.)